The Method in Use at the Cambridge Observatory of Measuring Differences of Right Ascension and North Polar Distance by an Equatoreal provided with Clock-movement, and of Correcting the Observations for Refraction. By Professor Challis.

"Differences of north polar distance are usually measured by the Northumberland equatoreal, by means of a small sector of a large circle, on the limb of which are inscribed equidistant divisions, separated by an arbitrary but ascertained interval. A similar sector can be clamped to any part of the hour-circle, and differences of right ascension measured in an analogous manner. This is effected by an arrangement contrived by Mr. Airy (who contemplated the kind of observation here described), by which the instrument may be moved about its polar axis independently of the hour-circle, while the latter is carried nearly at the rate of sidereal time by a clock. The hour-circle sector has been substituted for the hour-circle itself, because the divisions of the latter are on brass, and not so well adapted for accurate bisection as those of the sector, which are on white metal; and because the equi-distance of the divisions, which is the essential condition, is more likely to be secured in a small portion of a circle than in a complete circle. The intervals of both sectors are subdivided by microscope-micrometers. The following is the method of taking the observations.

"It is generally required, and always desirable, to measure simultaneously differences of right ascension and north polar distance. Accordingly the object is bisected by the equatorially adjusted wire, *very near* the transverse wire, so that the rate of the clock, gaining or losing as the case may be, soon brings it upon the latter wire, the observer taking care, in the meantime, that it remains bisected by the other. The instant of simultaneous bisection by the two wires is noted, and the microscope-micrometers of the two sectors are then read off in integral intervals and revolutions, and parts of a revolution. This process is *commenced with the star*, or point of reference; the object referred is next observed in the same manner, and so on alternately, the series *concluding with the reference star*. In case the compared object be too faint for observation with micrometer wires, the practice with the Cambridge equatoreal is to use a diaphragm bounded by straight edges at right angles to each other, and the object being placed near the angular point in the prolongation of the edge which is equatorially adjusted, the instant at which its centre is brought into coincidence with the angular point by the clock's rate is noted. In other respects the operation is the same as that just described. The chronometer is compared with the transit-clock at the end of the series (sometimes, also, before its commencement), and finally the barometer and thermometer are read off.

"With respect to the reduction of the observations, the chief things to remark upon are the corrections for the clock's rate, and

for refraction. The differences of the hour-circle sector readings for the *star* are entirely due to these two causes, if the instrument be supposed to be in good adjustment. The star being known, and the times of bisection known, the effect of refraction on the hour angles are calculated for each observation of the star, by a process which will be presently stated. Corrections for refraction being applied to the hour-circle sector readings for the star, the remaining differences are due to the clock's rate, and, by comparison with the times of bisection, determine the rate. The *correction for rate of hour-circle* is a part of the loss or gain in the interval between *consecutive* bisections of the star, which bears the same ratio to the whole, as the interval from either bisection of the star to the bisection of the planet or comet bears to the interval between the two bisections of the star. The following is the formula for this correction, the sidereal times of the three bisections, in the order of their occurrence, being s_1, σ, s_2; H being the excess of the hour-circle sector reading for the star at s_1 above the reading at s_2 converted into time; and R the excess of the correction for refraction in hour-angle for the star at s_1 above that at s_2 :—

$$\text{Correction for rate of hour-circle} = \frac{\sigma - s_1}{s_2 - s_1}(\mathrm{H} + \mathrm{R}).$$

This formula gives the quantity to be *added* to the algebraic excess of the sector reading for the comet or planet, above that sector reading for the star which was taken at the time s_1, and is sufficient for all cases.

"It is to be remarked, that if the difference of the sector readings be affected by any other source of error acting proportionally to the time, as, for instance, want of adjustment of the instrument, such error is eliminated by the above calculation. For this reason, to ensure greater accuracy, the excess of the reading of the *declination* sector for the compared object, above that for the star at the time s_1, is also corrected by the process just indicated, although that excess is unaffected by the clock's rate. The formula for this purpose is precisely the same as that given above; H, in this case, representing the excess of the declination sector reading for the star at s_1 above the reading at s_2, converted into arc; and R the excess of the correction for refraction in north polar distance for the star at s_1 above that at s_2.

"After applying the corrections now considered, it is presumed that the instrumental measures of differences of apparent right ascension and north polar distance are affected only by refraction. The total refractions for the star in R.A. and N.P.D. have been already required, and therefore the obvious course is to calculate, also, the total refractions for the planet or comet, and thence deduce the differences of refraction corresponding to the measured differences of R.A. and N.P.D. It may be questioned, whether any approximate formulæ, requiring only the calculation of differences of refraction, would lead to a less amount of calculation in this kind of observation. If P be the pole of the heavens, Z the

zenith of the observer, S the place of the object, and Z Q be drawn a perpendicular on P S, the formula used for the total corrections for refraction in R.A. and N.P.D. are the following:—

Correction for refraction in N.P.D. $= A. \tan (PS - PQ)$

Correction for refraction in R.A. $= A. \frac{\tan ZQ}{15}. \text{cosec. } PS. \sec (PS - PQ)$

The factor A is given by the tables in Bessel's *Astronomische Untersuchungen*, vol. i. pp. 198, 199, the argument in the case of the star being the *true* zenith distance, which is obtained by the formula sec. Z S = sec. Q Z sec. (P S — P Q). The argument in the case of the compared object is the *apparent* zenith distance, which is deduced from the same formula, the apparent N.P.D. and hour-angle being first obtained by applying the corrections for refraction in N.P.D. and R.A. of the star (with signs changed) to its true N.P.D. and R.A., together with the measured differences of N.P.D. and R.A. affected only by refraction.

"The above calculations will be much facilitated by two tables, one containing the values of P Q, log. sec. Q Z, and log. $\frac{\tan QZ}{15}$ (to five figures) for every minute of hour-angle from 0^h to 6^h, which will be found to require interpolations only to first differences, and which is, in fact, merely an expansion of the table mentioned in the *Monthly Notices*, vol. viii. No. 9, p. 210. The other is a table for obtaining the factor A. It will save much trouble, and be sufficiently accurate to take account of the barometer and thermometer by the empirical formula given in the *Monthly Notice* above cited, viz.:

$$\text{Log } A = \log k + 0{\cdot}015 \, B + 0{\cdot}001 \, (100° - T),$$

in which log k is log α or log α' of Bessel, according as the argument is the true or the apparent zenith distance, diminished by the constant 0·49572. Any error which the use of this formula induces, will very nearly disappear in the *differences* of the refractions. Thus the second table need merely consist of values of log α — 0·49572, and log α' — 0·49572; and the most convenient argument is log. sec. Z S, the consecutive logs. differing by 0·01. This table would, therefore, very well range with the table of values of log. α'' — 0·4957, required in the computation of differential refractions."

Professor Mädler having expressed a wish that certain stars should be re-observed in the southern hemisphere, the President and Council forwarded the request to Mr. Maclear, with a recommendation to comply with it, if convenient. We have received from Mr. Maclear the reduced observations, and the results are published here as the readiest way of communicating with Professor Mädler.*

* A letter was sent to Professor Mädler, offering to procure for him the Catalogues of Johnson, Taylor, &c., but it probably never reached him.

Mean Places of Southern Stars for January 1, 1847.

B.A.C.	R.A.	Mean R.A.	Ann. Prec.	Obs. in N.P.D.	Mean N.P.D.	Ann. Prec.
		h m s	s		° ′ ″	″
88	26	0 17 37·76	+2·582	43	168 6 57·7	−19·996
483	12	1 29 30·38	2·226	20	148 55 18·4	18·545
681	20	2 4 15·25	2·201	17	141 34 36·2	17·179
1044	11	3 13 49·30	2·116	17	133 39 28·8	−13·301
2151	15	6 27 53·62	+1·734	21	135 11 49·6	+ 2·435
2262	13	6 46 43·42	−1·198	16	162 56 49·7	4·060
2721	10	8 0 24·83	+1·684	20	140 9 21·5	10·059
5719	22	16 52 20·82	5·881	20	155 31 27·3	+ 5·835
6248	13	18 16 45·19	5·172	31	147 36 31·1	− 1·465
6804	15	19 43 11·16	6·232	20	159 9 23·0	8·727
7575	18	21 38 9·64	4·264	17	146 58 46·2	16·335
7656	18	21 51 36·75	4·182	22	147 24 37·9	16·990
7816	21	22 17 16·58	4·524	23	158 15 45·5	18·074
8080	17	23 4 30·58	3·459	21	140 26 56·7	19·470
8249	11	23 35 13·88	3·859	18	169 38 26·6	19·938
8260	18	23 38 25·10	+3·185	19	132 23 42·6	−19·966
3479	4	10 4 21·63	+1·700	6	154 45 42·1	+17·557
3481	4	10 4 26·70	+1·681	8	155 4 1·5	+17·559

Nos. 3479 and 3481 are not given in Mädler's list, but were observed on account of their proximity to the place assigned to No. 3482 of the B.A.C., which latter star *does not at present exist.*

Collecting from the various authorities the positions in R.A. and N.P.D., on which the place of 3482 depends, and bringing them up to January 1, 1847, by precession alone, we obtain

		R.A.		N.P.D.
		h m s		° ′ ″
Lacaille (4184)	... ...	10 3 27·4		154 51 30·9
Brisbane (2870)	2 obs. by mural	10 4 18·1	3 obs.	154 51 44·2
	3 do. by transit	10 4 19·5		
Rümker (196)	2 obs.	10 4 27·9		154 52

In the B.A.C. Rümker has been taken as the modern authority for R.A. and Brisbane for N.P.D.; the difference of 1^m between the R.A.'s of Lacaille and Rümker being attributed to proper motion of the star. On referring to the *Cœlum Australe Stelliferum*, the star observed by Lacaille will be found recorded in Zone x. April 26, 1752, "in parte inferiore," the times of ingress and egress being respectively $9^h\ 58^m\ 6^s$ and $10^h\ 3^m\ 20^s$. If 2^m be added to the time of egress, the place of the star for 1750 (employing the Reduction Tables given in the Catalogue of 9766 stars) will become

	h m s		° ′ ″
	10 1 42·2	N.P.D.	154 35 49
or brought up to 1847	10 4 25·2		155 4 7

The place for 1847 of B.A.C. 3481, from the Cape observations given above, is $10^h\ 4^m\ 26^s{\cdot}7$ N.P.D. $155^\circ\ 4'\ 1''{\cdot}5$. Thus the identity of Lacaille (4184) and B.A.C. 3481 is highly probable, and warrants the assumption of an error of 2^m in the original observations of the former.

The R.A. of Rümker (196) agrees pretty closely with the observed place of B.A.C. 3481, and the star observed by Brisbane in R.A. is probably identical with B.A.C. 3479; but his N.P.D. differs from that of the latter star by about 6′. Rümker has no observation in N.P.D. of (196); he gives the position to the nearest minute only.

The Astronomer Royal gave a description of the gigantic telescope erected by the Earl of Rosse, at Birr Castle, which he visited and carefully examined this autumn. The mode of grinding and polishing the speculum, the mounting, &c. were fully described and illustrated by models, and the residual difficulties stated. He also exhibited models of Mr. Lassell's grinding and polishing machine, and of the mounted instrument, dome, &c. It was clearly shewn that, though pursuing different courses, the Earl of Rosse and Mr. Lassell had each attained almost *absolute perfection* in figuring and polishing their specula, and that the difficulties in mounting, &c. were gradually overcoming by Lord Rosse, while they were already nearly got rid of by Mr. Lassell in his comparatively small instrument.

Mr. Drew, who has lately built and furnished a very convenient observatory at Southampton, adopts a collimating telescope for getting rid of his error of collimation. To this latter telescope he has attached a wire micrometer, which supplies the object to be viewed by the transit. He also uses the wire micrometer to measure the intervals of his wires. The results are more readily obtained than by slow moving stars, and he conceives with at least equal accuracy. Specimens of the determination of the intervals by both methods are given, which agree very nearly.

The Beaufoy Clock, which is lent by the Society to Mr. Drew, has been cleaned and set up in his observatory. Some remarkable irregularities have occurred in its rate, and when the weight and bob are nearly at the same height, the clock has stopped. In the present arrangement of the weight, it passes in front of the bob and about half an inch distant. Motion is communicated by the bob to the weight, either by the medium of the air or the play of the frame. It has been proposed to hang the weight on one side, out of the way, and so close to the clock-case as to touch it, in order that any oscillation may be prevented.

Hind's changing star has been carefully observed by Mr. Bond at Cambridge, U.S. "The colour is a brilliant red, not surpassed in intensity by any other star. With power 1500 there is no indication of a planetary disc. It was of the 6th magnitude on May 25th, and at our last observation had diminished to the 7·8th. There are thirty small stars within 6′ of it; and with one of these, of 15th magnitude, numerous observations of position and distance have been made at different times. The mean result is

1848·52 Position 212° 8′ Distance 116·″1

The differences from the mean are irregular and clearly accidental.

Mr. Bond remarks, that in the vicinity of *Procyon* three stars are missing, all within a few minutes' distance, viz. a star of 8th magnitude, Smyth's *Celestial Cycle*, p. 182, and both components of a double star 7th magnitude in Bessel's Zone 52.